Ask Dr. ALOHA:

Anatomy of the Concentration Graph: Part II

In the previous issue, we discussed how to obtain a Concentration graph for a location of particular concern such as a school or nursing home. For a given release scenario, this graph shows predicted pollutant gas concentrations in indoor and outdoor air at this location during the hour after an accidental chemical release begins. In this issue, we'll discuss some ways to interpret and use Concentration graphs.

Cloud speed and arrival time

In the previous issue, we met Susan, a Local Emergency Planning Committee (LEPC) member in River City who is using ALOHA to assess the potential hazard of an accidental chlorine release from the local water treatment plant. For each of several planning scenarios she has created, Susan used Concentration graphs to obtain predictions of the maximum gas concentrations in indoor and outdoor air to which people at two locations of concern, Central Valley Elementary School and St. Mary's Medical Center, might be exposed. Next, Susan wants to know to know how long after the start of a release it might take for a chlorine cloud to reach these locations.

She also can obtain this information from Concentration graphs. For example, Central Valley Elementary School is located 1 mile from the water treatment plant. How long might it take for a chlorine cloud to arrive at the school, if the wind were blowing directly from the plant towards the school? The speed that a cloud may travel depends on weather conditions, especially wind speed. It also depends on the nature of the cloud. ALOHA predicts that a neutrally-buoyant cloud travels at the speed of the wind, but that the speed of a cloud of a heavy gas such as chlorine may differ from the wind speed that you enter. This is because ALOHA expects a heavy gas cloud to be affected by the wind profile (which we will discuss in more detail in a future issue). This effect is accounted for in ALOHA's heavy gas model, but not in the Gaussian equation.

As the chlorine cloud passes over any point directly downwind of the release site, outdoor chlorine concentrations first rise as the leading edge of the cloud arrives, then later drop as the trailing edge of the cloud passes by.
Figure 1 shows the Concentration graph for Central Valley School for one of Susan's scenarios. After the start of a large chlorine release from the treatment plant, with wind speed at about 5 miles per hour, ALOHA predicts that it would take about 8 minutes for the outdoor chlorine concentration to exceed the level of concern (LOC) 1 mile directly downwind of the release point. In this scenario, the predicted outdoor chlorine concentration would drop below the LOC about 22 minutes after the beginning of the release. ALOHA predicts that the outdoor concentration would exceed the LOC for a total of 14 minutes (subtract 8 minutes from 22 minutes to obtain this time estimate). Note that ALOHA predicts the indoor concentration (shown as a dotted line on the graph) to drop much more

slowly; this is typical because it takes time for a pollutant gas to filter back out of buildings (bear in mind that ALOHA assumes doors and windows to be closed when it makes this prediction).

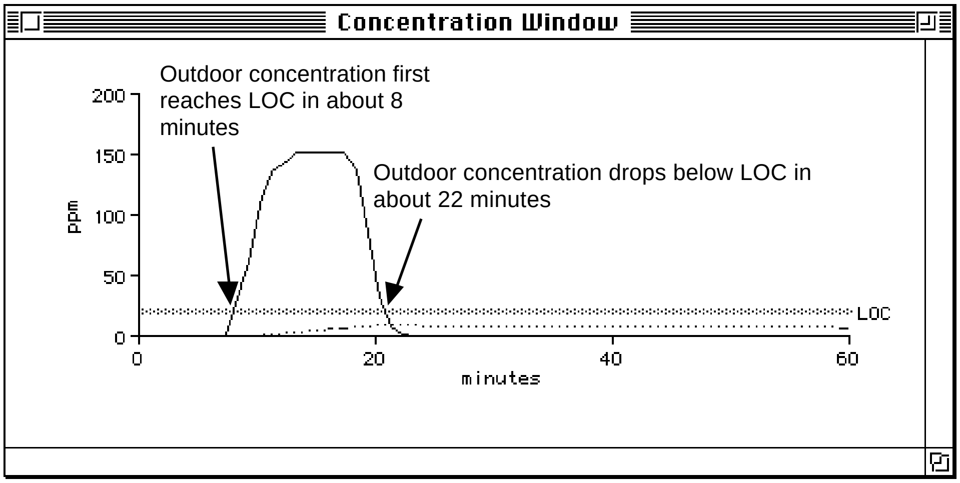

Figure 1. Concentration graph for a chlorine cloud passing over Central Valley School, located 1 mile downwind of the treatment plant. The LOC concentration has been drawn as a horizontal line on this graph. Outdoor chlorine concentration reaches the LOC about 8 minutes after the release begins. It drops below the LOC about 22 minutes after the start of the release.

Susan also can use the Concentration graph in Figure 1 to compute the chlorine cloud's average speed as it travels from the treatment plant to the school. In this example, the cloud travels about 1 mile (the distance from the treatment plant to the school) in 8 minutes (the time when the leading edge of the cloud reaches the school). There are 60 minutes in 1 hour, so this cloud is traveling at about 7.5 miles per hour, substantially faster than the speed of the wind. The calculations are:

$$\left(\frac{1 \text{ mile}}{8 \text{ minutes}}\right)\left(\frac{60 \text{ minutes}}{1 \text{ hour}}\right) = 7.5 \text{ miles / hour}$$

A caveat ALOHA assumes that the cloud travels across level terrain, and that its movement is not affected by hills, valleys, or obstacles such as large buildings. This assumption is correct in the case of River City, which is located on the level ground of an old floodplain. But it may not be true in your area. A dense, heavy cloud of a gas such as chlorine may travel more rapidly down a slope or steep valley than ALOHA predicts. Conversely, it may travel more slowly uphill. ALOHA also assumes that wind speed remains constant during the hour after a release begins. If the wind speeds up or slows down, a pollutant cloud could arrive at a location of concern at a much different time than ALOHA predicts. If the wind changes direction, the cloud might not arrive at that location at all. *As you evaluate its predictions, account for the ways in which ALOHA's assumptions may differ from the circumstances of a real event.*

When concentration reaches a maximum after an hour

You should be aware of a weakness in ALOHA 5.1, which will be corrected in the upcoming version. This has to do with how ALOHA presents concentration information for some locations far from a release point under certain circumstances. If a pollutant cloud is moving slowly away from its point of release because wind speed is low, more than an hour may elapse before it arrives at locations well downwind. For example, if a cloud is traveling at 4 miles per hour, it will take more than an hour for that cloud to reach a location more than 4 miles downwind. This means that at more distant locations, concentrations will increase and reach a maximum after an hour has passed. (However, because concentrations within a cloud decline with distance from the release point as the cloud spreads out and becomes diluted, maximum concentrations well downwind of a release will be much lower than maximum concentrations close to the point of release.)

Because weather conditions such as wind speed and direction change on a time scale of about 1 hour, ALOHA makes predictions only for an hour into the future. Bear in mind that for this reason, ALOHA cannot provide you with useful concentration estimates for locations more than an hour's travel downwind of a release. Instead, when you enter the coordinates of such a location into ALOHA, the model will report that there is "no significant concentration / dose" at that location. You will see this message in the Concentration window, as in Figure 2, as well as on the Text Summary screen. *However, depending on the scale of a release and the Level of Concern that you have selected, concentrations might reach significant levels at some locations more than an hour after the start of the release,.* In such a situation, to help you recognize that its predictions are only for the first hour after the start of any release, the upcoming version of ALOHA will report instead that concentration and dose do not reach significant levels *during the first hour*.

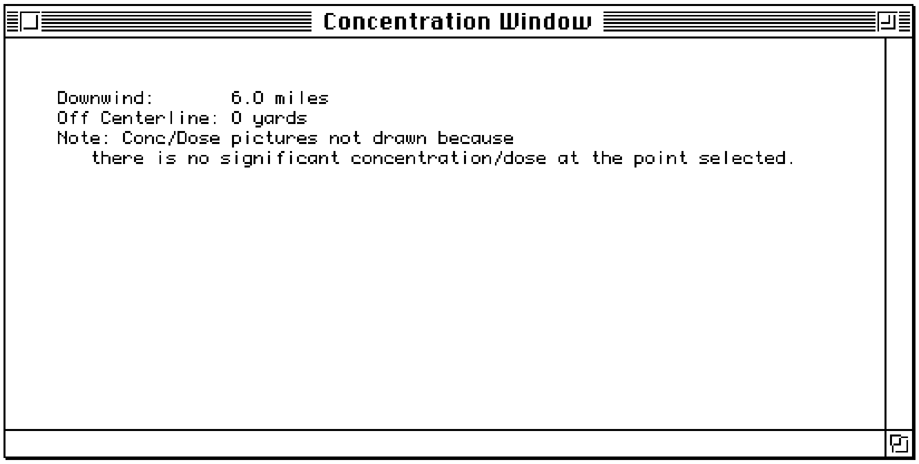

Figure 2. The Concentration window for a location more than an hour downwind of the release point.

Be aware as well that the maximum concentration estimates shown on ALOHA's Text Summary window always represent the maximum attained at a location of concern during the hour after a release begins. At distant locations, concentrations may increase beyond these values after an hour. *This information will not appear in ALOHA's text summary.*

An example

For example, Figure 3 shows part of ALOHA's Text Summary window for a large chlorine release, with wind speed at 3 miles per hour. The maximum outdoor concentration is displayed as 1.34 parts per million (ppm).

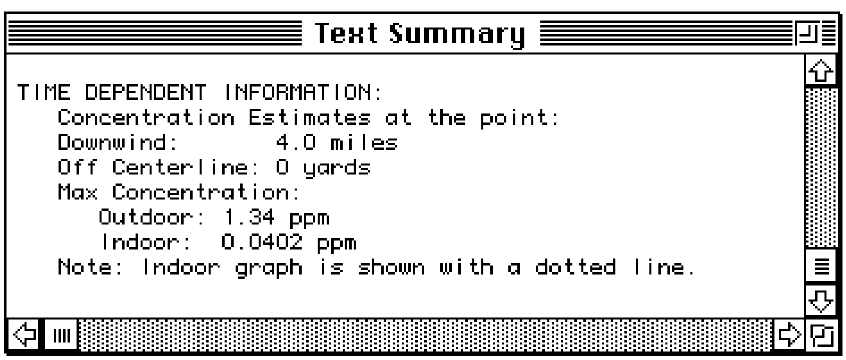

Figure 3. ALOHA's Text Summary window, showing a maximum outdoor concentration value of 1.34 ppm of chlorine gas at a location 4.0 miles downwind of the release point, and on the cloud centerline.

However, the Concentration graph for this location (Figure 4) shows that the maximum outdoor concentration of 1.34 ppm is attained exactly 1 hour after the start of the release, and that the concentration is continuing to increase sharply at that moment. It's clear from the graph that the concentration will eventually exceed the maximum concentration attained in 1 hour.

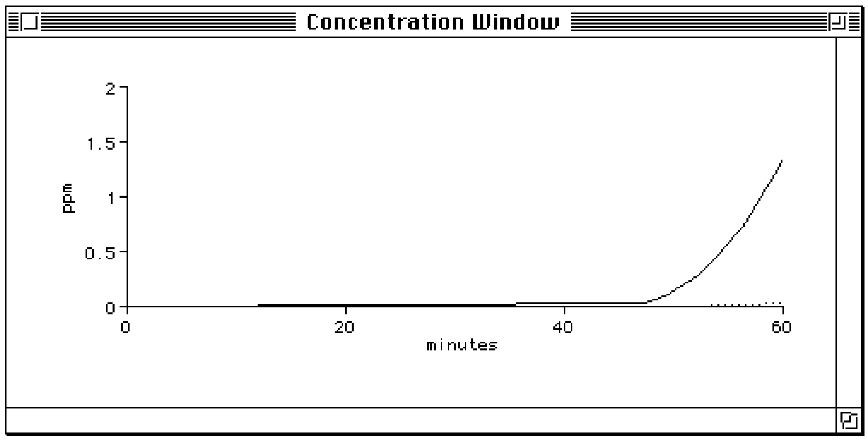

Figure 4. ALOHA's Concentration graph for the same location. The maximum concentration attained within an hour will be exceeded after an hour has passed.

The upcoming version of ALOHA will warn you if the concentration is predicted to increase more than an hour after the start of a release at a location that you select. And it will alert you that the maximum concentrations that it reports are maximums reached during the first hour only. For now, though, when you obtain concentration estimates for locations of concern, be sure to check not only the Text Summary screen, but the Concentration graph as well. Doing so will help you to see whether the Text Summary estimate is the maximum concentration that would ever be attained at that location for that release scenario, or if higher concentrations might be reached after more than an hour.

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